National Aeronautics and Space Administration

Parabolic Flight Investigation for Advanced Exercise Concept Hardware Hybrid Ultimate Lifting Kit (HULK)

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Abstract

- Long-duration space flight poses many hazards to the health of the crew. Among those hazards is the physiological deconditioning of the musculoskeletal and cardiovascular systems due to prolonged exposure to microgravity. To combat this erosion of physical condition space flight may take on the crew, the Human Research Program (HRP) is charged with developing Advanced Exercise Concepts to maintain astronaut health and fitness during long-term missions, while keeping device mass, power, and volume to a minimum. The goal of this effort is to preserve the physical capability of the crew to perform mission critical tasks in transit and during planetary surface operations.

- The HULK is a pneumatic-based exercise system, which provides both resistive and aerobic modes to protect against human deconditioning in microgravity. Its design targeted the International Space Station (ISS) Advanced Resistive Exercise Device (ARED) high level performance characteristics and provides up to 600 lbf resistive loading with the capability to allow for eccentric to concentric (E:C) ratios of higher than 1:1 through a DC motor assist component. The device's rowing mode allows for high cadence aerobic activity.

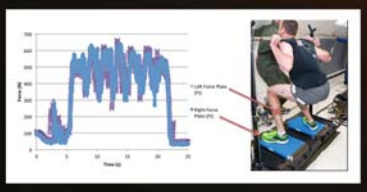
- The HULK parabolic flight campaign, conducted through the NASA Flight Opportunities Program at Ellington Field, resulted in the creation of device specific data sets including low fidelity motion capture, accelerometry and both inline and ground reaction forces. These data provide a critical link in understanding how to vibration isolate the device in both ISS and space transit applications. Secondarily, the study of human exercise and associated body kinematics in microgravity allows for more complete understanding of human to machine interface designs to allow for maximum functionality of the device in microgravity.

Objectives of Parabolic Flight Testing

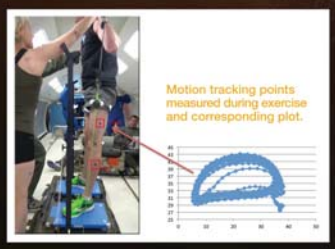
- Vibration Isolation System: Collect data from 0-g exercise for design and validation efforts
- Rowing add-on hardware tests
  - Tests performed with and without rowing guide track
- Functional testing of device in 0-g environment

Results and Discussion

- Force plates were used to capture left and right ground reaction forces (GRF) for each exercise
- This GRF data collections is critical to the development of a vibration isolation system for this and other exercise devices



- Markers were drawn on subjects during data collection at key locations for motion tracking purposes
- This allowed for basic joint tracking which will be useful for biomechanical modeling efforts



- Insole force sensors were worn in the subjects' shoes for exercises as well, this provided crucial data about foot reaction forces, particularly on exercises where using the force plates was not practical

Basic Features of the Device

- Load adjustable from 10 to 600 lb
- Cable outputs can perform virtually all short bar (single cable/side) and long bar (two cables) exercises
  - Short bar examples—curls, triceps extension, and rows
  - Long bar examples—squats, bench press, and dead lift

Long bar exercises, dead lifts (left) and single-sided operation, rows (right).